Louisiana

Acid Tolerance of Forage Species

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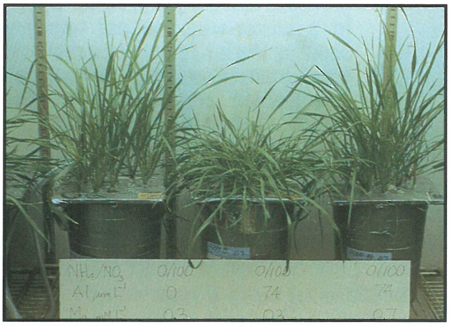
Louisiana studies have emphasized the varying sensitivity of cool-season and warm-season forage species to soil acidity and exchangeable soil aluminum (Al). Liming to reduce soil acidity and lower exchangeable Al is a crucial forage best management practice that has dramatic effects on the growth of most species, particularly legumes.

IN THE SOUTHEASTERN U.S., a wide variety of forage species is important for livestock production, many grown on highly acid soils. While some forage grasses are rather acid tolerant, many legumes are sensitive to high levels of soluble and exchangeable Al, the major factor restricting root growth and crop yields in acid soils. Yet, there is a continual interest in expanding legume production in order to increase forage quality and resultant animal productivity while reducing the use of nitrogen (N) fertilizers. If forage legumes or grasses are to be grown successfully on highly acid soils, their relative acid tolerance should be known so lime needs can be met as efficiently and economically as possible.



INCREASED concentrations of available Al associated with low soil pH dramatically decrease growth of annual ryegrass and other forages. From left to right, Al concentration in the pots was 0, 74 and 74 μmol/liter. Increased concentrations of available magnesium (Mg), however, offset the negative effects of Al. Magnesium concentrations left to right were 0.3, 0.3 and 0.7 mmol/liter.

Louisiana Studies

At Louisiana State University we conducted a greenhouse study to evaluate the relative Al tolerance of various forage grasses and legumes. A highly acid Stough fine sandy loam soil of the Flatwoods area with high levels of exchangeable Al and relatively low levels of soluble iron (Fe) and manganese (Mn) was selected. Thus acid soil toxicities could be attributed to exchangeable Al levels. Seven species of cool-season forages were grown at six levels of lime application: 0, 1.5, 3, 6, 12 and 24 tons/A. The experiment was repeated with seven warm-season species. Forage yields were then related to the resulting soil pH values and exchangeable Al levels.

Cool-Season Forage Yields

Forage yields clearly showed that Marshall ryegrass was more tolerant of a wide range in soil pH and Al values than were the clovers. It also produced about twice the maximum yield (**Table 1**). Ryegrass yield at pH 4.6 and 111 parts per million (ppm) Al where no lime was applied was only 21 percent of the maximum yield, while yields at all other pH values ranged from 78 to 96

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Table 1. Effects of soil pH and soil exchangeable Al on yields of cool-season forage species.

Soil pH	Soil Al, ppm	Ryegrass MRG[1]	Clovers OSC	S-1	SUB	DIX	CHF	BBS
		----------	----------	----------	grams/pot	----------	----------	----------
4.6	111	2.1d	0.2c	0.0c	0.1c	0.0c	0.0d	0.0c
4.7	77	8.5bc	2.4b	2.8b	3.3b	1.9b	1.3c	1.5b
5.2	36	10.2a	4.6a	4.8a	5.7a	5.8a	5.2a	3.8a
6.2	< 2	9.1abc	4.6a	4.2ab	3.9b	6.1a	4.2b	3.1a
7.5	< 1	9.8ab	0.8c	0.7c	0.1c	0.2c	0.0d	0.2c
7.8	< 1	8.0c	0.5c	0.6c	0.1c	0.1c	0.1d	0.2c

[1]MRG = Marshall ryegrass; Clovers: OSC = Osceola white; S-1 = La S-1 white; SUB = Mt. Barker subterranean; DIX = Dixie crimson; CHF = Chief crimson; and BBS = Bigbee berseem.

Table 2. Effects of soil pH and soil exchangeable Al on yields of warm-season forage species.

Soil pH	Soil Al, ppm	Grasses COM[1]	DAL	BAH	Legumes AES	SER	176	ALY
		----------	----------	----------	grams/pot	----------	----------	----------
4.4	91	18.4ab	13.6b	14.9ab	2.8a	0.0b	0.4b	0.2c
4.5	59	18.3ab	16.8a	16.4a	2.8a	3.8a	2.5a	2.2b
4.8	39	20.1a	15.2ab	15.3a	3.4a	4.7a	3.0a	2.4b
5.7	4	15.8b	15.6ab	12.8b	4.6a	4.8a	3.8a	5.8a
7.2	<1	18.8a	5.4c	1.9c	0.7b	0.0b	0.3b	0.1c
7.6	<1	19.3a	0.7d	0.0c	0.0b	0.0b	0.0b	0.0b

[1]COM = common bermudagrass; DAL = dallisgrass; BAH = Pensacola bahiagrass; AES = Aeschynomene; SER = Serala lespedeza; 176 = Interstate 76 lespedeza; and ALY = alyce clover.

percent of the maximum yield. All cool-season species produced the highest yield at pH 5.2 and 36 ppm Al, except Dixie crimson clover, which produced the highest yield at pH 6.2 and 1 ppm Al. However, Dixie produced 95 percent of the maximum yield at pH 5.2.

Mt. Barker subterranean and Chief crimson were the only clovers that produced significantly less forage at pH 6.2 than at pH 5.2. The most Al-tolerant clovers were Mt. Barker subterranean, Osceola white, and La S-1 white, which still produced 53 to 59 percent of their maximum yields at pH 4.7 and 77 ppm Al. The crimson clovers and Bigbee berseem clover were least Al tolerant and produced only 24 to 40 percent of maximum yield at 77 ppm Al.

The surprisingly high levels of Al tolerance of all the cool-season clovers are possibly related to the high organic matter content (3.9 percent) in this soil. None of the cool-season clovers produced acceptable yields without lime application at pH 4.6 and 111 ppm Al or at pH values above 7.0.

Warm-Season Forage Yields

Warm-season forage grasses were much higher yielding and more Al tolerant than were the forage legumes (**Table 2**). Common bermudagrass produced satisfactory yields over the entire pH range from 4.4 to 7.6, with Al levels up to 91 ppm.

Dallisgrass and bahiagrass each produced maximum yields at pH 4.5 and 59 ppm Al and showed very little yield fluctuations at other acid pH values. Dallisgrass produced 81 percent of maximum yield at pH 4.4 and 91 ppm Al, and bahiagrass produced 78 percent of maximum yield at pH 5.7 and 4 ppm Al, both yields being significantly lower than the maximum yield. Other yield differences of either species were not significant at acid pH values. Neither grass produced acceptable yields at pH values above 7, although dallisgrass appeared somewhat more alkaline tolerant than did bahiagrass.

Each of the warm-season forage legumes produced the maximum yield at pH 5.7 and 4 ppm Al. Aeschynomene

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GROWTH of ryegrass was severely limited where no lime was applied (at left). Plot shown at right received 1 ton/A lime application, which increased yield and soil pH.

date. In contrast, Marshall variety produced 658 lb/A dry matter at first harvest on plots receiving 1 ton/A lime and 868 lb/A on the 4 tons/A lime plots. Marshall, Tetragold, Surrey and Jackson varieties produced significantly higher yields with liming than did Gulf, Florida 80 and TXR-91-A7EF.

Summary

Fall applications of good quality agricultural lime to acid soils prior to ryegrass seeding is an important management practice for acceptable forage yields. Liming increased soil pH, increased exchangeable Ca, lowered exchangeable Al, advanced forage harvest and increased yields. ■

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was the most Al-tolerant legume in that it produced 60 percent of the maximum yield at pH 4.4 and 91 ppm Al, while other legumes produced very little growth at that Al level. However, Serala lespedeza produced more growth at 39 and 59 ppm Al than did aeschynomene. Serala also produced more growth than did Interstate 76 lespedeza at all Al levels. Alyce clover was the least Al-tolerant species, producing only 41 and 38 percent of maximum yield at 39 and 59 ppm Al. None of the legumes produced significant growth at pH values above 7.

Summary

Common bermudagrass and Marshall ryegrass were both tolerant of highly acid and alkaline soil, although ryegrass yield was severely depressed at pH 4.6 and 111 ppm of exchangeable Al. Dallisgrass and bahiagrass were highly Al tolerant, but yields were greatly reduced in alkaline soil. None of the legumes grew well at alkaline pH values. Cool-season clovers produced maximum yields at pH 5.2 and 36 ppm exchangeable Al while warm-season legumes, which are generally considered more acid tolerant, produced maximum yields at pH 5.7 and 4 ppm exchangeable Al. Reasons for these differences are being investigated. It is encouraging that legumes can be productive on this highly acid Flatwood soil with as little as 3 tons/A of applied lime. ■